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PROTECTIVE LAYER

Field Of The Invention

The present invention relates to a protective layer which is relatively permeable for CO_2 and is relatively impermeable for SO_2.

Background Information

Such a protective layer is used, for example, to protect a CO_2-sensitive polymer layer of a smoke detector from damage or contamination due to SO_2. Such a CO_2-sensitive polymer layer is used as a gas sensor in a smoke detector to detect a CO_2 content in a room where the smoke detector is installed. The CO_2-sensitive polymer layer preferably has a membrane composed of a polymer matrix (e.g., polydimethylsiloxane), an auxiliary base (tetraalkylammonium hydroxide) and a pH-sensitive dye (e.g., thymol blue or other derivatives). When this CO_2-sensitive membrane is exposed to CO_2, it leads to reversible reactions, preferably detectable by an optical element, in particular also by electrical or mass-sensitive elements, thus permitting an inference regarding the CO_2 content in the room monitored.

However, when this CO_2-sensitive membrane comes in contact with SO_2, it leads to irreversible reactions in the sensor material and thus to destruction of the CO_2-sensitive feature of the sensor. Since this reaction of the sensor membrane to SO_2 is irreversible, SO_2 reaction products accumulate on the membrane, so that even a low SO_2 concentration will damage the sensor membrane over a period of time and decreases its CO_2 sensitivity, so that a smoke detector equipped with such a CO_2-sensitive membrane sensor will ultimately become useless.

Known protective layers are designed as compressed powder pellets or granules which are

relatively impermeable for SO_2 but relatively permeable for CO_2. Likewise, there are known molecular filters which utilize differences in the molecular structure of the CO_2 molecules and are thus relatively impermeable for SO_2 molecules and relatively permeable for CO_2 molecules. However, one disadvantage when such a protective layer is used to protect a CO_2 sensor is that the CO_2 molecules must first penetrate through this protective layer to reach the CO_2 sensor. Accordingly, the period of time needed for the CO_2 molecules to reach the CO_2 sensor may be greatly prolonged. This increase in time has an especially serious effect when the CO_2 molecules are in movement merely due to their temperature-related kinetic energy (Brownian motion) in the absence of a directional flow, which is usually the case in propagation of smoke in the event of a fire. When such a protective layer is then used in a smoke alarm, the response time of the smoke alarm is increased due to the period of time required for the gas molecules to penetrate through the protective layer; in other words, the period of time until the CO_2 sensor detects an elevated CO_2 concentration is longer.

Summary Of The Invention

The protective layer according to the present invention, however, has the advantage that the CO_2 molecules need only a relatively short period of time to penetrate through the protective layer. When using the protective layer according to the present invention in a smoke alarm, this yields the advantage that the lengthening of the response time of the smoke alarm due to the protective layer is reduced.

The present invention is based on the finding that the oxidation product of SO_2, namely SO_3, is a strongly oxidizing and hygroscopic acid anhydride which reacts further immediately to form a sulfate (SO_4^{2-}). However the resulting sulfates may be deposited on the carrier material, so that sulfates are adsorbed in the protective layer.

SO_2 molecules thus accumulate on the carrier and are stored there, while CO_2 molecules can penetrate through the protective layer without reacting. Theoretically, a single contact of an SO_2 molecule with the carrier surface provided with the oxidizing agent is sufficient to trigger the above-mentioned reaction, so complicated structures (such as those in a compressed powder pellet, for example) need not be formed in the protective layer to guarantee this one

contact with a probability bordering on certainty. Accordingly, CO_2 molecules need not penetrate through any complicated protective layer structure, so that CO_2 molecules can penetrate through the protective layer according to the present invention in a relatively unhindered and undelayed manner.

According to a preferred embodiment, the carrier may have at least one tube whose inside wall is provided with the oxidizing agent. In this embodiment, the SO_2 molecules and the CO_2 molecules penetrate through this tube axially, in which case there is a probability according to the laws of probability for the molecules striking the inside wall of the tube coated with the oxidizing agent. Due to this contact, an SO_2 molecule may become adsorbed on the carrier while a CO_2 molecule will rebound away from it without reacting and will continue on its way. The value for this adsorption probability can be determined as a function of a mean length of free path of the molecules by using a ratio of the cross section of the tube to the length of the tube.

Brief Description Of The Drawings

Figure 1 shows a longitudinal section through a first embodiment of the protective layer according to the present invention.

Figure 2 shows a perspective view of a second embodiment of the protective layer according to the present invention.

Figure 3 shows a side view of a third embodiment of the present invention.

Figure 4a shows a side view of a fourth embodiment of the protective layer according to the present invention.

Figure 4b shows a top view of a fourth embodiment according to the present invention.

Detailed Description

According to Figure 1, a smoke detector 3 is mounted on a wall 2 in a room 1, in particular on a room ceiling; in the event smoke develops in room 1, this smoke detector should deliver a warning signal accordingly. For this purpose, smoke detector 3 has a CO_2-sensitive sensor 4 equipped with a CO_2-sensitive membrane 5. In addition, smoke detector 3 has a carrier 10, which is designed here as a cylindrical tube 6, in particular a round cylindrical tube. In this embodiment, this tube 6 is part of a protective layer 7 according to the present invention which is marked by figure bracket 7. CO_2 sensor 4 here is separated from room 1 by this protective layer 7, i.e., by tube 6.

Tube 6 is mounted in an airtight mount on smoke detector 3 on one axial end, so that tube 6 encloses CO_2 sensor 4. The axial end of tube 6 opposite CO_2 sensor 4 is open and exposed to a gas present in room 1. An inside wall 8 of tube 6 is provided with a coating 9 of a nonvolatile oxidating agent. For example, potassium permanganate may be used as the oxidizing agent. Tube 6 may be made of aluminum oxide, for example.

The protective layer according to the present invention functions as follows:

As soon as an SO_2 molecule strikes inside wall 8 of tube 6 (the path of motion of such an SO_2 molecule is represented by an interrupted line), the SO_2 molecule is oxidized to an SO_3 molecule by the oxidizing agent, forming manganese dioxide (MnO_2). The acid anhydride SO_3 immediately reacts further to (SO_4^{2-}) and combines with released potassium compounds to form K_2SO_4. The solids formed by these reactions, namely MnO_2 and K_2SO_4, are deposited on inside wall 8 of tube 6, so that to this extent the SO_2 molecules are adsorbed by carrier 10 of layer 7 or by tube 6. Tube 6 is preferably made of a corrosion-resistant material that is resistant to sulfuric acid media, so that neither SO_2 nor SO_3 molecules nor (SO_4^{2-}) can damage tube 6.

In contrast with an SO_2 molecule, a CO_2 molecule (its path of motion represented by a solid line) is not adsorbed on inside wall 8 of tube 6, but instead is deflected, so that the CO_2 molecule can strike membrane 5 of CO_2 sensor 4 without any great delay. As soon as a sufficient quantity of CO_2 molecules striking membrane 5 has triggered the proper response, smoke alarm 3 delivers the warning signal.

According to Figure 2, carrier 10 of protective layer 7 according to the present invention may also be designed as a block which may be composed of a plurality of axially parallel cylindrical tubes 6 arranged side by side. In this embodiment, tubes 6 have a rectangular cross section, in particular a square cross section. Here again, inside walls 8 are provided with oxidizing agent coating 9.

Such block-like carriers 10 can be produced especially easily from monolithic catalysts, which then need only be provided with oxidizing agent coating 9.

According to Figure 3, carrier 10 of protective layer 7 may also be designed as a block, individual tubes 6 aligned radially with respect to a straight line perpendicular to the plane of the drawing or a point 11. In the specific embodiment illustrated in Figure 3, tubes 6 are not cylindrical in shape but instead they have a cross section tapering in the direction of the point or line 11. This embodiment allows molecules to penetrate into tubes 6 from a large solid angle range, so that CO_2 molecules can reach CO_2 sensor 4 from practically all directions.

According to Figures 4a and 4b, carrier 10 of protective layer 7 is again formed from a block, which here is composed of multiple grids 12 stacked one above the other, each being formed by a plurality of intersecting grid rods 13. Individual grids 12 need not be aligned with one another and stacked as in Figures 4a and 4b, and instead individual grids 12 may also be arranged with an offset. Oxide coating 9 here is applied to the surface of grid rods 13. The probability of adsorption is determined by the number of grids 12 stacked together and by their mesh; in other words, this is the probability that an SO_2 molecule penetrating into protective layer 7 will strike the surface of one of grid rods 13 and will react with the oxidizing agent there, thus being adsorbed in protective layer 7.